

NHDOT SPR2 PROGRAM

RESEARCH PROGRESS REPORT

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a progress report at least every three months during the project duration. Reports are due the 5th of the month following the end of the quarter. Please provide a project update even if no work was done during this reporting period.

Project # 26962G		Report Period Year: 2017 <input type="checkbox"/> Q1 (Jan-Mar) <input type="checkbox"/> Q2 (Apr-Jun) <input checked="" type="checkbox"/> Q3 (Jul-Sep) <input type="checkbox"/> Q4 (Oct-Dec)
Project Title: The Living Bridge: A Benchmark for Bridge Monitoring The Living Bridge: Tidal Turbine Deployment System		
Project Investigator: Erin S. Bell Project Co-Investigators: Martin Wosnik, Kenneth Baldwin Phone: (603)862-3850 E-mail: erin.bell@unh.edu		
Research Start Date: sample July 1, 2016	Research End Date: September 30, 2018	Project schedule status: <input type="checkbox"/> On schedule <input type="checkbox"/> Ahead of schedule <input checked="" type="checkbox"/> Behind schedule

Brief Project Description:

This project is a collaborative project between the civil and environmental engineering, mechanical and ocean engineering programs at UNH, the NHDOT and several industrial partners to install of an array of structural health monitoring, environmental and estuarine sensors on the Memorial Bridge in Portsmouth, New Hampshire that will be powered by a tidal turbine attached to one of the bridge piers. The funding for the Tidal Turbine Deployment System is leveraged with funding provided by the National Science Foundation's Partnerships for Innovation (PFI) Program, The Living Bridge: The Future of Smart, Sustainable User-Centered Transportation Infrastructure.

Progress this Quarter (include meetings, installations, equipment purchases, significant progress, etc.):

Benchmark for Bridge Monitoring:

The final instrumentation plan for the structural health monitoring was discussed at the June 28th 2016 technical advisory group meeting in Concord, NH, and was approved on July 18 2016. The structural sensors were installed on the bridge structure in March 2017. The installation was complete on March 8 2017. The sensors are operational and reading data - at present to the BDI office. The integration with the local server and database is being finalized with Northeast Integration and was completed in August 2017. June/July 2017). The integration of sensors data is still underway and local control of the sensors was established for the marine sensors in August 2017 and is anticipated for the structural sensors in October 2017.

The structural model of the Memorial Bridge in SAP2000® is complete. This model is for the Portsmouth span and lift tower only. Graduate student, Timothy Nash, conducted a study of wind loads developed from AASHTO, ASCE7-10 and European codes to predict the structural response of the lift tower. Tim defended his thesis and graduated with his masters degree in December 2016. A journal paper on this work will be submitted in October 2017. This information will be compared to the measured structural response of the tower, once the data integration is completed.

A detailed model of the gusset-less truss connection in ABAQUS® is completed. The response from this model is the basis for a quantitative set of stiffness values (stiffness matrix) to represent the connection in the structural SAP® model.

A set of full-scale and multi-scale models of the bridge and connection was developed at UNH in Lusas®. This program was chosen to mirror the modeling done during bridge design by HNTB. A comparison of Lusas® models with the SAP® model is shown that they are in good agreement with each other in preparation for calibration with collected field data from the load test that will be conducted in October 2017. The load test was originally scheduled for Summer 2017 but in addition to delays related to data integration the core processor of the Bridge Diagnostic INC data acquisition unit was corrupt and was replaced in September 2017 after several attempted fixes. The core is functioning properly and once the data integration connection with the database is reestablished the "mock" load test to test the data acquisition protocols

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without the test truck will be conducted in early October.

The strain gauges on the vertical guide posts will be installed once the conduit installation of the tidal turbine connection is completed. This installation will be completed by Bridge Diagnostics, INC and coordinated with the NHDOT for October 2017. We are working to coordinate the load test with the installation so that bridge Diagnostic, INC can lend their expertise to the load test. The potential dates for this installation and load test are October 16-18 and October 23-25 2017. We are working with NHDOT finalize this schedule.

PI Bell continues to communicate with bridge designer, Ted Zoli, both in live and virtual meetings. The last conference call as held on April 14th 2017 and the next live meeting in New York is planned for Fall 2017.

Tidal Turbine Deployment System

The tidal turbine deployment system consists of vertical guide posts (VGPs) and a turbine deployment platform (TDP) on which the tidal turbine will be installed.

The VGP installation by Pepperrell Cove Marine was completed on 13 December 2016. The TDP was first test-deployed at the bridge for one tidal cycle on 31 March 2017 (spring flood tide). After modifications to the pile guide system and installation of the marine instrumentation the TDP was redeployed at the Memorial Bridge on 22 June 2017 by marine contractors Pepperrell Cove Marine. and has remained attached to the VGP at the bridge since then.

After the redeployment of the TDP UNH personnel remained on the platform for a tidal cycle, followed by in-person inspection during peak currents for each tidal cycle. The UNH team has continued to perform in-person inspection and maintenance on the instrumentation and TDP, arriving by boat from the UNH Pier in New Castle, NH. After the close monitoring during the initial deployment period, the inspection and maintenance trips were conducted twice per week. After observing the TDP in operation for some time and after a webcam was installed at Portsmouth Harbor Cruises to monitor the TDP, the team felt comfortable to reduce the inspection and maintenance trips to once per week.

Over the course of the summer the marine instrumentation has been collecting data. The instrumentation on the TDP is believed to already have created some of the longest datasets of their kind for these research purposes in the estuary.

Electrical conduit and cables have been run to the pier cap of Pier No. 2 by project partner Northeast Integration (NEI). These cables will be run out to a droop under the bridge deck which will serve as the data and power connection to the TDP.

A turbine pitching mechanism (TPM) was designed to support the tidal turbine and deploy it through the TDP moon pool. The TPM is currently in fabrication.

UNH is expected to receive shipment of the tidal turbine this fall. UNH has contracted with Pepperrell Cove Marine to assemble the TPM and install the turbine. To do this the platform will be removed from the bridge and the TPM (with the turbine mounted to it) will be lifted onto the TDP and bolted to the TDP by Pepperrell Cove. Pepperrell Cove will then tow the TDP back to the Bridge for turbine operation.

The instruments are currently connected through a temporary connection to the bridge; a permeant solution with conduit installed by NEI is currently being worked in. The power and communication connections from the TDP to the Memorial Bridge have been designed and discussed. An on-site meeting at the bridge regarding power connection was held on 9/8/2017 with Jeff Stevens of NEI, UNH personnel and Dave Leboe of Instream Energy Systems (calling in from Vancouver, BC). Electrical and data/control connection of the turbine and TDP were discussed. A set of electrical drawings made by Instream Energy Systems were given to NEI, both via email (PDF) and in hardcopy.

The energy coming from the tidal turbine will be grid-tied via an inverter and net-metered, using a separate enclosure and separate disconnect. The net-metering approach is the simplest and most efficient/effective from an electrical connection point of view. Our turbine partners, Instream Energy Systems, have experience with these types of grid-tie inverter systems, the hardware they propose to use (Siemens SINAMICS S120 drive system) is UL 1741 certified. Our local integration partner for instrumentation, data systems and power, Northeast Integration of Portsmouth, NH, is intimately familiar with power supply and cabling on Memorial Bridge, and will design and implement the turbine electrical connection. UNH and NEI have discussed net-metering with the distributed generation manager at Eversource, the local utility. The

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bridge owner, NH DoT, needs to ask Eversource to install a power meter that can run in reverse, should the tidal turbine ever produce more power than the bridge and instrumentation can use. The maximum power output of the turbine at peak flow during spring tides will be 10 kW.

The Living Bridge

In August graduate students Ian Gagnon and Kaelin Chancey presented on the Living Bridge Project at the 2017 European International Network on Offshore Renewable Energy (INORE) Symposium at The Burren, Co. Clare, Ireland. Kaelin Chancey was awarded the best presentation at the symposium.

Graduate students Ian Gagnon and Kaelin Chancey with summer interns Mallory Cashman and Ian Wilson shot video for a video to be created by the NH Marine docents which highlights work being done on the turbine deployment platform.

PI Bell presented the Living Bridge Project to the faculty at the University of Johannesburg-Auckland, South Africa during an outreach trip in July 2017.

PI Bell presented the Living Bridge Project at the Co-PI at the 12th International Conference on Structural Safety and Reliability in Vienna, Austria on August 6-10, 2017.

Bell, E., Mashayekhizadeh, M. Adams, T. and Nash, T. (2017). "Structural Monitoring to Support Decision-Making a Vertical Lift Bridge", ICOSAAR, Vienna, August 6-10.

Items needed from NHDOT (i.e., Concurrence, Sub-contract, Assignments, Samples, Testing, etc):

UNH will need access protocols for the data closet at the bridge for maintenance of the data acquisition system.

UNH will require access to the pier cap for strain gauge installation on the VGP by Bridge Diagnostics, INC, during October 2017. Preferable installation and testing dates are October 16-18 or October 23-25. We have started discussions with Gene Popien to finalize this schedule.

UNH will require the NHDOT support for the load test.

UNH will need the NHDOT to decide on the future of the memorialbridgeproject.com website. Currently, the site is hosted at UNH and the domain name will expire in December 2017. The high school intern, funded through the NSF project, designed a new project website: <https://livingbridge.unh.edu>

NHDOT needs to ask Eversource to install a power meter that can run in reverse, should the tidal turbine ever produce more power than the bridge and instrumentation can use. The maximum power output of the turbine at peak flow during spring tides will be 10 kW.

Anticipated research next 3 months:

Benchmark for Bridge Monitoring:

The integration of the structural health and environmental instrumentation the sensors for remote access is scheduled for completion in July 2017. The load test will occur in October 2017. The long-term data collection triggers will be in place for lift-operation and other events by November 2017.

The validation of the structural models of the Memorial Bridge in Lusas® as well as local model of selected gusset-less connections at the Memorial Bridge with respect to collected data in Fall 2017. Calibration of the structural models for condition and performance assessment with respect to design verification. .

Strain gauges will be installed by BDI on the VGPs.

Tidal Turbine Deployment System

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The deployment of tidal turbine deployment platform (TDP) with estuarine sensors at the Memorial Bridge occurred in June 2017. The installation of the tidal turbine on the deployment platform is planned for fall of 2017, with power and communication connection to be installed in October 2017 by NEI.

The turbine is expected to be delivered this fall. It will be mounted to TDP and then towed to the bridge. Commissioning and initial testing will then commence. UNH will then operate the turbine throughout the winter.

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Circumstances affecting project: Describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope, and budget, along with recommended solutions to those problems.

As described in the “Progress this Quarter” section of this report, the schedule delay and increased cost related to the electrical conduit negatively impact this project.

Tasks (from Work Plan)	Planned % Complete	Actual % Complete
Living Bridge: Creating a Benchmark for Bridge Monitoring		
Project Coordination	100	100
Structural Model Creation	100	90
Design the instrumentation Plan	100	100
Sensor Deployment	100	95
Data Collection and Model Calibration	75	60
Incorporation of collected data and model into NHDOT protocols	0	0
Final Report and Adoption Recommendation	0	0
Tidal Turbine Deployment Structure		
Deployment Structure Design	100	100
Project Permitting	100	100
Installation of Support Posts	100	100
Procurement of the Turbine deployment barge	100	100
Site Installation	100	100
Electrical Connection	100	50
Final Report and Poster	0	0